PSEUDOTACHYLITES IN METEORITES: FRICTION MELTING AS AN ALTERNATIVE TO SHOCK DARKENING. C. H. van der Bogert and P. H. Schultz, Brown University, Dept of Geological Sciences, Box 1846, Providence, RI 02912.

Background:

Darkening in black and gas-rich ordinary chondrites results from poorly graphitized carbon in the matrix, or a dispersion of the metal fraction [1]. Shock processes are widely accepted to be the mode for dispersing metals through the meteorites and causing darkening [2]. However, many "shock darkened" meteorites may not be darkened by shock processes but may be darkened by the formation of pseudotachylites during impacts between the meteorite parent bodies. We propose that these darkened meteorites could be impact darkened by frictional processes rather than shock.

Friction Melts:

Pseudotachylite (Figure 1) is comprised of an extremely fine grained groundmass (< 5 microns) with randomly dispersed angular to subrounded quartz and feldspar clasts of widely variable size [3]. Some clasts may be partially or completely assimilated and are referred to as ghost clasts [4]. A variety of diffuse and sharp contacts exist between clasts or the host rock, and the groundmass [3]. Clasts of pseudotachylite may also be included within a subsequently formed pseudotachylite, as seen at the Vredefort structure in South Africa [4].

The groundmass of comprised of mafic minerals, which are mechanically weaker and are thus comminuted before the stronger felsic minerals. This process is responsible for the darkening of the pseudotachylite with respect to the host rock and for dispersing metals throughout the groundmass. Metal oxide globules are present in the groundmass. Stringers or small veins of oxides crosscut the host rock in close proximity to the pseudotachylite and enter it where diffuse boundaries are present [3]. Pseudotachylite

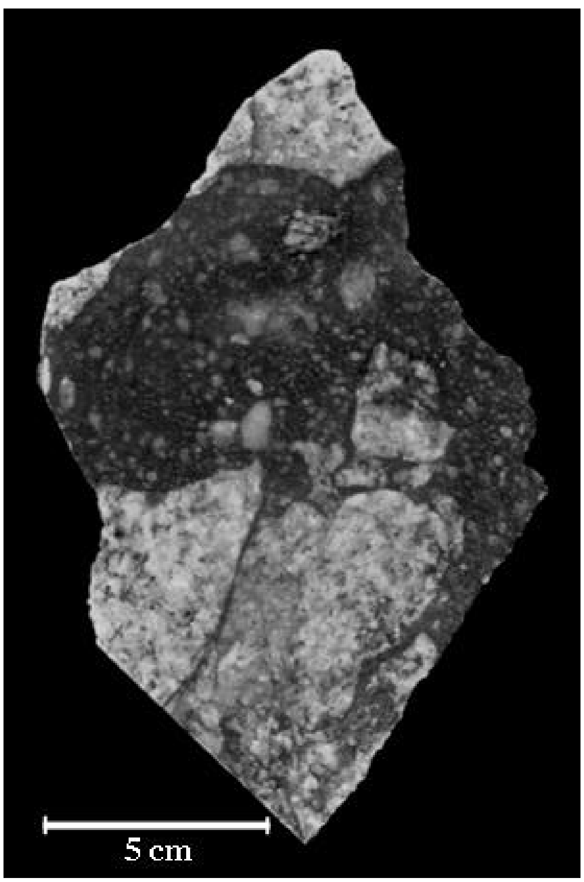

Figure 1. Pseudotachylite from the Vredefort structure, South Africa.

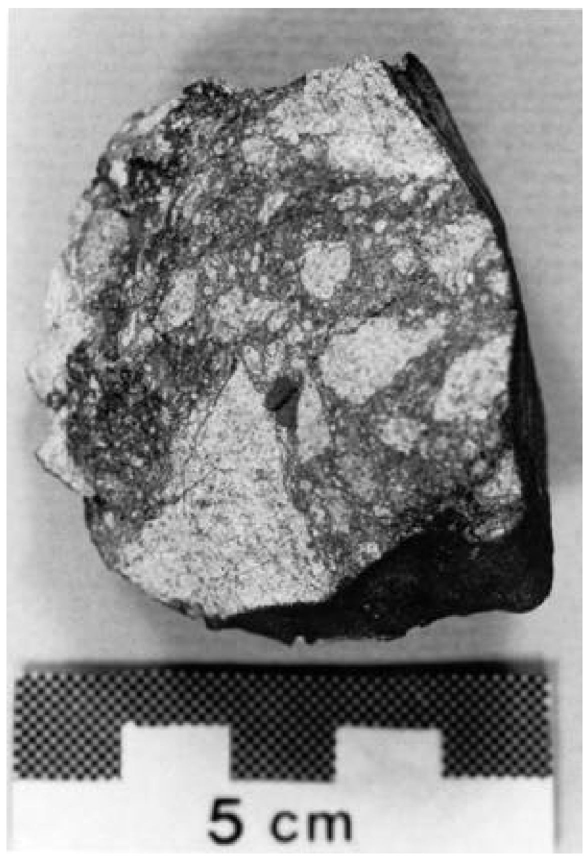

Figure 2. Gas-rich ordinary chondrite Dwaleni (H6) [5].

exhibits distinct injection veinlets which crosscut the host rock [3]. Flow structures are defined by the alignment of biotite and other mafic grains in the groundmass [3]. Major contacts with the host rock may exhibit chilled margins [3].

In meteorites, features observed in "shock darkened" meteorites (Figure 2) include aphanitic to microcrystalline groundmass containing relict silicates of a wide range of sizes from angular to subrounded [6] [7] [8]. Clast boundaries are well defined in some areas and are diffuse where they intersect shock veins [9]. These relationships are seen in pseudotachylites as sharp and diffuse contacts and as ghost clasts. Some clasts , referred to as "pseudo-clasts", in meteorites have similar chemical properties to the surrounding host rock indicating that the clasts where derived in situ [10]. Other observations show that clasts are generated from pre-existing rocks with different chemical signatures [9].

Discussion:

Terrestrial pseudotachylite is a high strain rate rock which is formed in faults and during impacts as a result of fracturing and progressive comminution. The clasts then undergo surface melting, fragment to fragment adhesion, and the formation of a fragment-laden, melt-supported suspension [11]. Pseudotachylite may be referred to as a friction-melt or friction-melt breccia. The physical expression of pseudotachylites in terrestrial rocks strikingly resemble darkened areas in some meteorites. The underlying process producing friction melting is generally attributed to large-scale displacements or "super faults" over short periods of time [12].

Observations of clasts within the shock darkened matrix of certain meteorites resemble clasts in pseudotachylite. First, shocked and unshocked clasts are observed in darkened areas in meteorites [7] [8]. This is consistent with the Vredefort pseudotachylite which contains shocked quartz and feldspar clasts and is present with other shock indicators such as shatter cones [4]. Second, darkened areas in meteorites contain globules of metal dispersed throughout the groundmass, and stringers or veins of metals, sulfides, or oxides extending into surrounding host rock [1] [2] [6] [7] [8]. Finally, textural and mineralogical features are not aligned parallel to the edge of the darkened areas [9] and crosscut the host rock [6]. Such clastic and melt textures, in fact, have been attributed to frictional melting [7].

The low gravity on even the largest asteroids should not lead to a driving mechanism comparable to terrestrial pseudotachylites. Nevertheless, oblique impacts appear to enhance heating of both impactor and target materials through frictional as well as shock processes [13][14]. Consequently, it is possible that major oblique collisions could lead to frictional melting and pseudotachylite formation without the role of gravity [14].

Conclusions:

Stöffler, et. al. [6] recognized that the small metal and oxide veins in meteorites could be the result of shearing and frictional melting analogous to the production of micro-pseudotachylites in grains in terrestrial impact rocks. We propose, in light of the similarities described above, that in addition to forming micro-scale veins, that shearing, frictional melting, and formation of pseudotachylites during oblique asteroid impacts could contribute to many of the other characteristics present in meteorites at a larger scale. Survival of sheared impactor debris may be even more likely due to the effects of target surface curvature that allow impactor products to survive collision [15].

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